ECONOMIC GEOLOGY OF PORTIONS OF DEL NORTE AND SISKIYOU COUNTIES, NORTHWESTERNMOST CALIFORNIA

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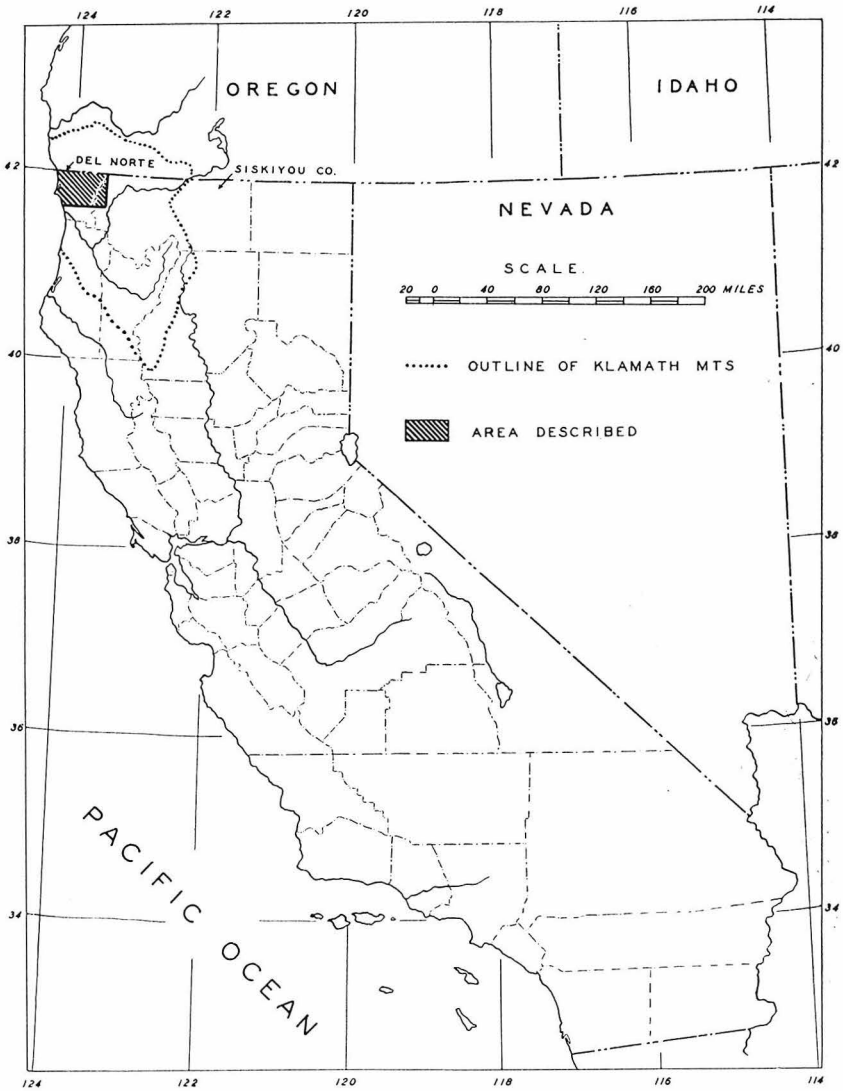

FIG. 1. Index map of California showing location of area described.

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INTRODUCTION

Location

The region described in this paper occupies the extreme northwestern corner of the State of California extending inland about 36 miles from the Pacific Ocean and southward about 20 miles from the Oregon boundary. It includes the northern portion of Del Norte County and a small northwestern fraction of Siskiyou County. It is in part represented topographically on the Preston Peak quadrangle (41°30′–42° N, 123°30′–124° W), which contains the western end of the Siskiyou Range, a northwesterly member of the Klamath Mountains group.

Klamath River, the trunk stream of northern California and south central Oregon, flows through the southern portion of the area. Smith River, to the north, drains the major basin within Del Norte County.

Physical Conditions

Northwesternmost California is mountainous with some peaks attaining an elevation of over 7000 feet. The region is heavily forested, the temperate and humid climate being favorable to a multitude of plant types.

The Redwood Highway, formally completed in 1928, traverses this part of California and greatly increases its accessibility. The interior mountain area is served by a few United States Forest Service

roads and by a network of trails. Here horses and pack trains are as necessary as in the earliest days of settlement.

Lack of suitable transportation facilities has impeded development of mineral resources. Products of Del Norte County are commonly carried by wagon or truck to the harbor at Crescent City, the county seat, whence they are transferred to vessels in coastwise shipping and distributed. The Redwood Highway now renders fairly accessible the Southern Pacific railroad facilities at Grants Pass, Oregon, some 66 miles by airline northeast of Crescent City.

Previous Work

The general geology of the area described in this report has almost escaped the attention of geologists. A notable exception is afforded by a very brief account of the economic geology of Del Norte County by O. H. Hershey,[1] based upon a reconnaissance made in 1907. This paper is accompanied by an areal map showing the general distribution of formations, the only one thus far published.

The physiography is in part discussed by Diller[2] in "The Topographic Development of the Klamath Mountains."

Mineral resources of the region have been described by Hershey,[3] Diller,[4] Lowell,[5] Aubury,[6] and others.[6a]

The most recent report on the mineral resources by C. McK. Laizure,[7] includes the description of a number of properties not visited by the writer.

Object of Report

The mineral deposits discussed in this report were studied in connection with a program of research in the geology of the western Siskiyou Mountains carried out under the supervision of Professor J. P. Buwalda. Most of the deposits are not being exploited at present and many have not been worked in over a decade. Some occurrences have potential economic value, depending upon market and possible improvements in transportation. The study has been made, however, not from the standpoint of a mining engineer interested in future production, reserves, ownership, etc., but rather from the scientific aspect in regard to geological setting and genesis.

SUMMARY OF GEOLOGY

The northwesternmost corner of California may be divided physiographically into three parts. Along the Pacific Ocean is the coastal province including the shoreline belt and the sub-rectangular emerged marine terrace upon which Crescent City is situated. Immediately

[1] Hershey, O. H., Del Norte County geology: Min. and Sci. Press, vol. 102, p. 468, 1911.

[2] Diller, J. S., Topographic development of the Klamath Mountains: U. S. Geol. Survey Bull. 196, 1902.

[3] Hershey, O. H., Black Diamond (Del Norte County, California): Min. and Sci. Press, vol. 98, p. 147, 1909.

[4] Diller, J. S., Chromite in the Klamath Mountains, California and Oregon: U. S. Geol. Survey Bull. 725-A, pp. 1–34, 1921.

[5] Lowell, F. L., Del Norte, Humboldt, Mendocino counties: Cal. State Min. Bur., Rept. XIV, pp. 373–391, 1916.

[6] Aubury, L. E., Copper resources of California: Cal. State Min. Bur., Bull. 23. pp. 97–116, 1902.

[6a] Cal. State Min. Bur., Bull. 50, pp. 133–140, 1908.

[7] Laizure, C. McK., Del Norte County: Cal. State Min. Bur., Rept. XXI, pp. 281–294, 1925.

inland is a country of plateaus and accordant ridges separated by deep canyons, a region increasing in altitude from about 1400 feet near the high sea cliffs to over 3000 feet at the western base of the Siskiyou Range proper. This region was reduced to a peneplain before late Miocene time, was locally warped and uplifted in the early to middle

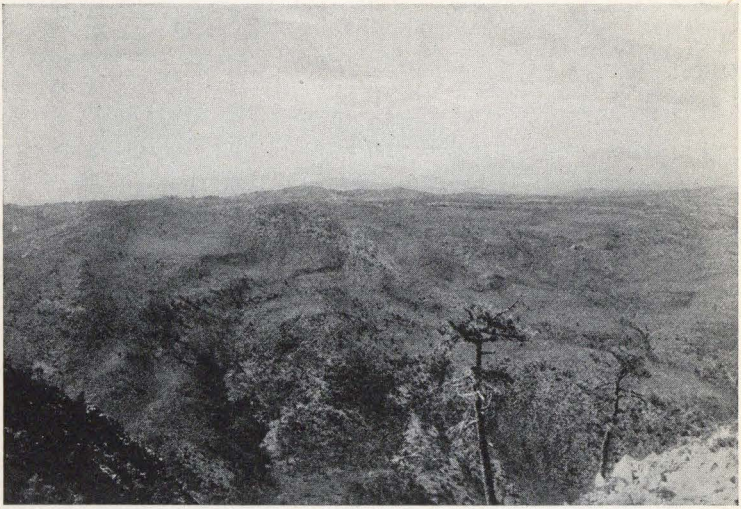


FIG. 2. Looking north at level summit of Pine Flat Mountain, a remnant of the Klamath oldland, over the gorge of the north fork of Smith River. Topographic illustration of relationship between surfaces of the former and present erosion cycles.

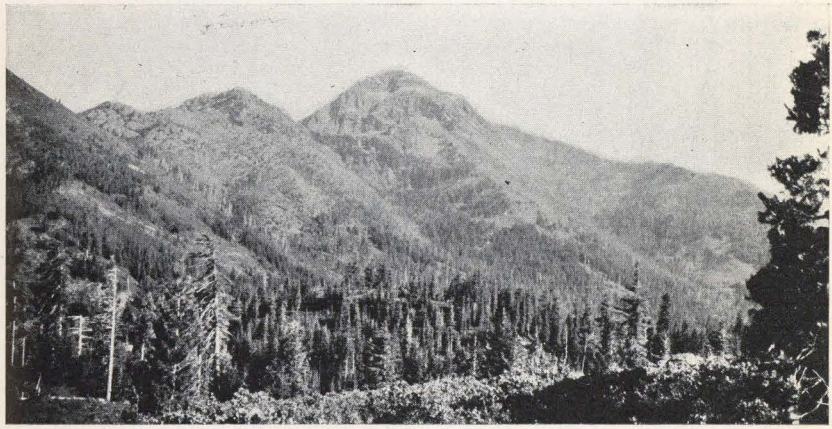


FIG. 3. Preston Peak from the north.

Pliocene, and was reduced later to a surface of low relief. Renewed uplift in the early Pleistocene initiated the present cycle. This region as a whole may be referred to as the Klamath oldland province. The third province may be termed the Siskiyou upland because it includes the mountain peak and valley topography of the western Siskiyou

Range and possesses elevations up to 7310 feet above sea level (Preston Peak). The range was moderately glaciated in the Pleistocene.

The oldest formations are largely found in the Siskiyou upland and the youngest in the coastal province. The stratigraphic section is tremendously complicated and is witness to a long and varied geologic history. Igneous rocks preponderate over the entire area and include the range from rhyolite to basalt, from granite to peridotite.

Algonkian(?)

Schists

As in other parts of the Klamath Mountains, there are two general groups of schists which in the area described, however, were not observed in contact. The characteristic rock of the one group is a quartz mica schist. Hershey [8] originally described the unit as the Abrams formation and considered it pre-Cambrian. In the Port Orford quadrangle of Oregon, Diller [9] described quartz-mica schists as the Colebrooke formation. In the occurrences observed in Del Norte County quartz-mica schist is subordinate to interbedded phyllite and slate. The formation represents a dynamo-metamorphosed series of shales and argillaceous sandstones.

The second group of schists is characterized by hornblende folia separated by quartz and feldspar. Hershey [10] described this rock as the Salmon hornblende schist. From studies in the southeastern Klamath Mountains, Hinds [11] concludes that the Salmon formation represents a metamorphosed series of basic-lava flows. He has grouped the two sets of schist under the name 'Siskiyou terrane.'

In the Preston Peak quadrangle the Salmon formation occurs in isolated patches, as pendants in various intrusive masses.

Devonian

Grayback formation

This formation outcrops in the northeastern corner of the Preston Peak quadrangle where it consists of over 5000 feet of argillites, cherts, limestone (in part marble) and interbedded flows of basalt. Fossils collected by Diller [12] were determined by E. M. Kindle as representing Devonian. The formation is in some respects similar to the Kennett formation (middle Devonian) of Shasta County.

Late Paleozoic(?)

Preston diorite

The Preston hornblende diorite (named from occurrence in Preston Peak) intrudes the Grayback formation and is intruded by serpentine and by the Siskiyou granodiorite. Thus in age it may come anywhere in the great interval between Devonian and late Jurassic. While con-

[8] Hershey, O. H., Metamorphic formations of northwestern California: Am. Geologist, vol. 27, p. 225, 1901.

[9] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Port Orford folio (No. 89), 1903.

[10] Hershey O. H., *op. cit.*

[11] Hinds, N. E. A., Paleozoic eruptive rocks of the southern Klamath Mountains, California: California Univ. Dep. Geology Bull., vol. 20, pp. 375–410, 1932.

[12] Diller, J. S., Mineral resources of the Grants Pass quadrangle and bordering districts, Oregon: U. S. Geol. Survey Bull. 380, pp. 50–51, 1909.

clusive field evidence is at present lacking, the intrusion is likely to prove to be late Paleozoic in age. Certain dioritic and gabbroic intrusives to the southeast have been considered by Hinds[13] to be probably of Paleozoic age.

The Preston diorite is commonly a fine-grained, gray rock closely cut by quartz veinlets. Green hornblende is more characteristic than brown, though both occur. Moderately calcic plagioclase is the other important constituent. Minor amounts of quartz and orthoclase are sometimes present in granodioritic facies.

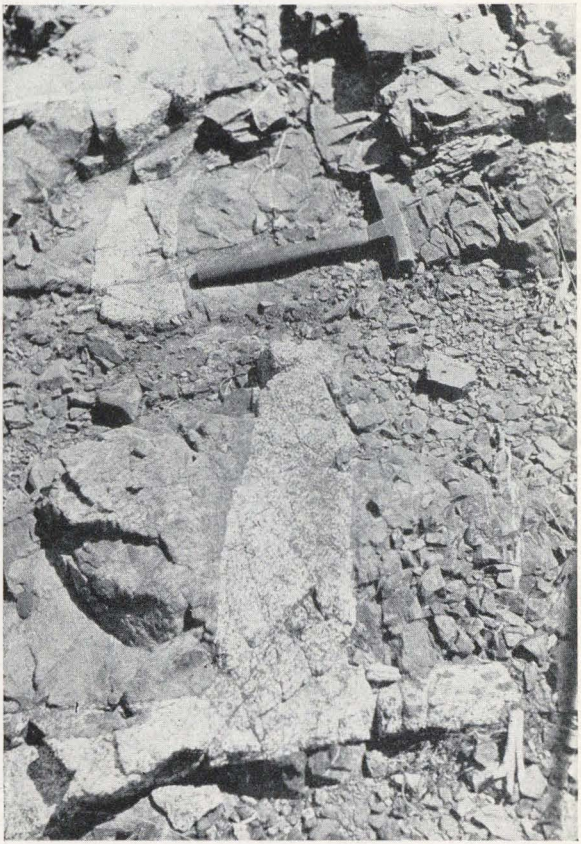


FIG. 4. Dike of Siskiyou granodiorite penetrating Preston hornblende diorite.

Jurassic

Galice formation

The Galice formation named by Diller [14] for its occurrence in southwestern Oregon consists of dynamo-metamorphosed argillites preponderantly, with associated sandstones and fine conglomerates. These are intruded in places by dikes and sills of rhyolite. Fossils collected by

[13] Hinds, N. E. A., *op. cit.*, p. 406.

[14] Diller, J. S., The Mesozoic sediments of southwestern Oregon: Am. Jour. Sci., 4th ser., vol. 23, pp. 404–405, 1907.

Diller near the type locality indicate late Jurassic age. He regarded the formation as a correlative of the Mariposa slates of the Sierra Nevada.

Several areas of argillites and slates of doubtful correlation are shown on the map as Galice. The area represented as Grayback forma-

FIG. 5. Galice? slates exposed by Redwood Highway cut on Smith River.

tion near the central portion of the map may eventually prove to be Galice.

Dothan formation

The Dothan formation also named by Diller [15] from occurrence in Oregon has been traced by Butler and Mitchell [16] southwesterly to the California line. Two sandstones are prominent, one a bluish rock on fresh fracture which weathers to a gray, the other a brown sandstone containing black shale pebbles. Shales and cherts are less abundant rock types. Some basalt and rhyolite flows are interbedded. The formation as a whole is less metamorphosed than the Galice to which it roughly corresponds in age. While in some respects lithologically similar to the Franciscan formation with which it has been correlated,[17] considerations of proximity and continuity favor use of the local name.

Serpentine

With this rock type are included the widespread ultrabasic intrusives, saxonites and dunites, as well as moderately transformed meta-

[15] Diller, J. S., *op. cit.*, p. 402.

[16] Butler, G. M., and Mitchell, G. J., Preliminary survey of the geology and mineral resources of Curry County, Oregon: Oregon Bureau of Mines, Min. Res. Ore., vol. 2, p. 2, 1916.

[17] Louderback, G. D., The Mesozoic of southwestern Oregon: Jour. Geology, vol. 13, pp. 514–555, 1905.

Hershey, O. H., Del Norte County geology: Min. and Sci. Press, vol. 102. p. 468, 1911.

peridotites. Practically none is absolutely unaltered by hydrothermal metamorphism. The group has great areal extent in the Klamath Mountains where its age relationship is less clear than in the Coast Ranges. The large batholiths of Del Norte County intrude the Galice and Dothan formations (late Jurassic) and the Preston diorite. They are intruded by the Siskiyou granodiorite, a correlative of the Sierra Nevadan granodiorite, and are therefore considered late Jurassic.

Many of the economic deposits, particularly chromite and copper, are associated with serpentine or meta-peridotite.

Siskiyou granodiorite

The granodiorite is a coarse-grained plutonic rock containing green hornblende, biotite, sodic plagioclase, orthoclase, and quartz. Apatite and magnetite occur as accessory minerals. Facies with quartz low in amount or absent are monzonites. With orthoclase also low in amount the principal rock type grades into a diorite. This type is of widespread occurrence. Augite characterizes a related group of rocks, the augite diorites, outcropping principally in the Klamath oldland province. Complementary dikes of hornblende-biotite granite cut the batholith. A similar petrologic group from southwestern Oregon has been described by Winchell.[18]

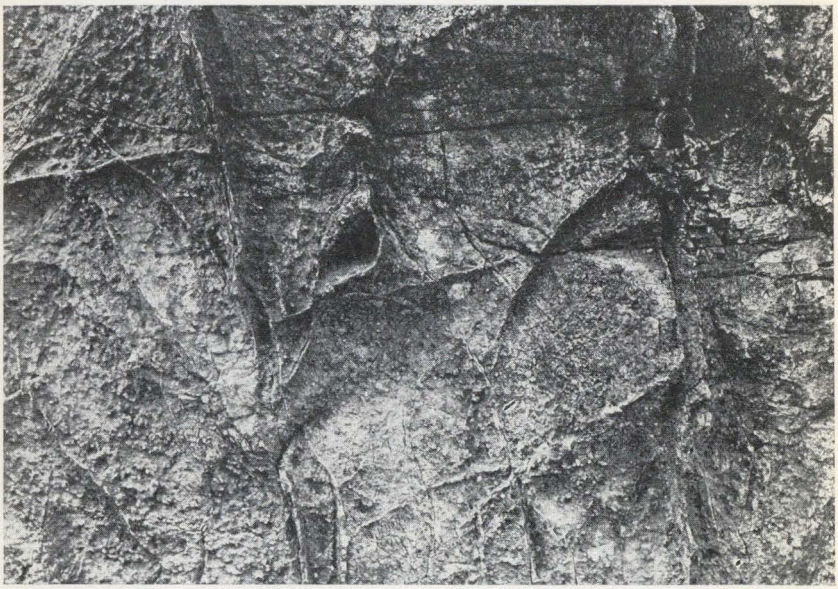


FIG. 6. Surface aspect of weathered metaperidotite, quartz veinlets and chlorite crystals in relief.

This group of rocks is correlated with the granodiorites of the Sierra Nevadan batholith of late Jurassic age. The Siskiyou granodiorite was observed to intrude the Preston diorite (Fig. 4) and ser-

[18] Winchell, A. N., Petrology and mineral resources of Jackson and Josephine counties, Oregon: Oregon Bureau of Mines, Min. Res. Ore., vol. 1, no. 5, pp. 45–46, 1914.

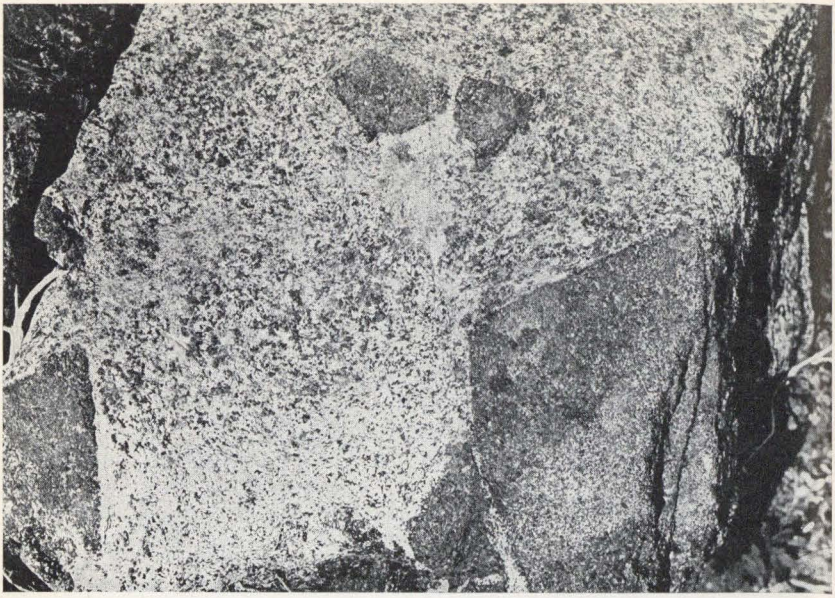


FIG. 7. Siskiyou granodiorite with xenoliths of peridotite.

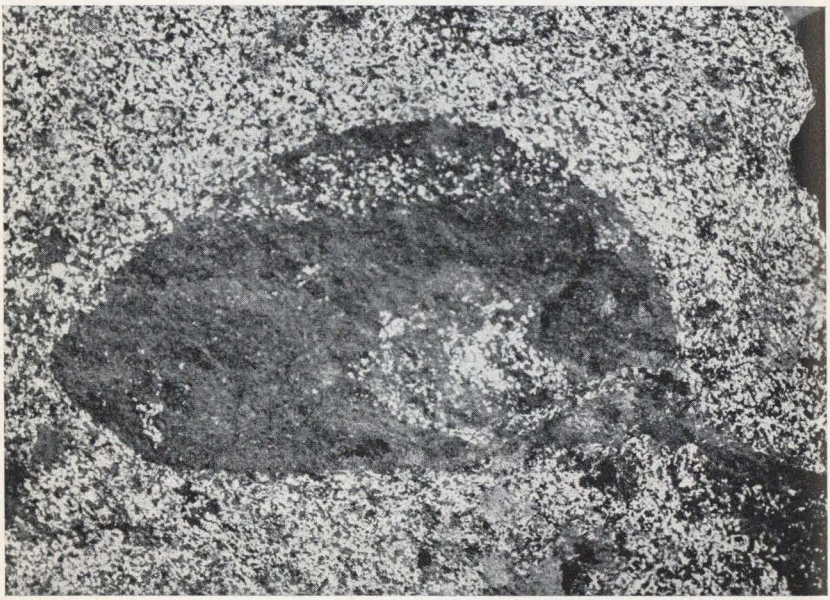


FIG. 8. Siskiyou granodiorite with autolith of hornblendite.

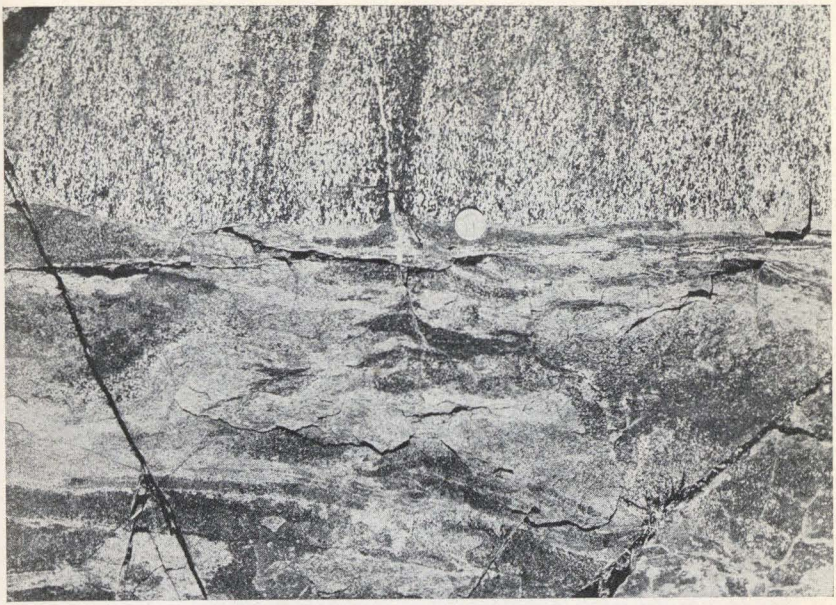


FIG. 9. Siskiyou granodiorite showing flow banding of hornblende crystals cut by lamprophyric dike with flow structure.

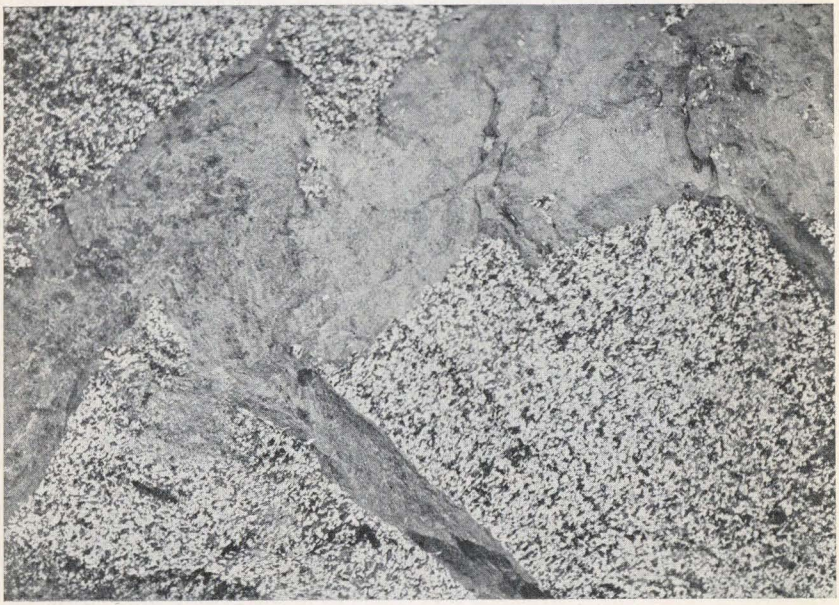


FIG. 10. Siskiyou granodiorite cut by lamprophyric dike.

pentine, but to be intruded by the Patrick greenstone of supposed Cretaceous age.

It is believed that the magma from which this rock was formed introduced the gold of the region and some of the copper.

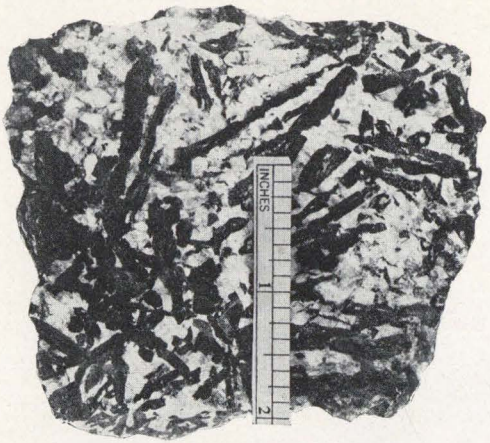


FIG. 11. A pegmatitic facies of Siskiyou granodiorite showing development of large hornblende crystals.

Cretaceous (?)

Patrick greenstone

Greenstone is sometimes loosely used by miners and prospectors for fine-grained greenish rocks commonly containing green hornblende, pyroxene, or chlorite. The rocks included under this category in the present paper are fine-grained intrusive diorites and andesites containing green hornblende and sodic plagioclase with smaller amounts of sericite and pyrite. With quartz present they grade into quartz diorites and dacites, being occasionally porphyritic. The rock exists in various stages of hydrothermal alteration.

In Oregon, Butler and Mitchell [19] observed greenstone cutting lower beds of the Myrtle, a Cretaceous formation. In southwestern Oregon the greenstone is not known to invade the Arago formation (Eocene) and is, therefore, believed to be of Cretaceous age.

Miocene

Wimer formation (Wymer formation of Diller)

The Wimer formation consists predominantly of shales containing kaolin and diatoms with interbedded sandstones and fine conglomerates having a maximum thickness of 150 feet. It is flat-lying and exposed on plateau tops east of Crescent City.

[19] Butler, G. M., and Mitchell, G. J., *op. cit.*, pp. 31–32.
[20] Diller, J. S., Topographic development of the Klamath Mountains: U. S. Geol. Survey Bull. 196, p. 33, 1902.

A flora submitted [20] to F. H. Knowlton was determined as upper Miocene. The marine molluscan fauna contains *Pecten discus* Conrad thus confirming this age determination.

Pliocene (?)

St. George formation

This northeasterly dipping marine formation consists of sandstones and shales carrying an abundant fauna of invertebrates. The total thickness exposed near Point St. George is somewhat under 100 feet but it is presumably considerably thicker. It lies nonconformably on the Dothan formation (Jurassic) and is overlain nonconformably by the Battery formation (Pleistocene).

Dall [21] has correlated the St. George formation with the beds exposed at Cape Blanco, Oregon, and with the Empire formation of Coos Bay. Beds at one time exposed beneath the wharf at Crescent

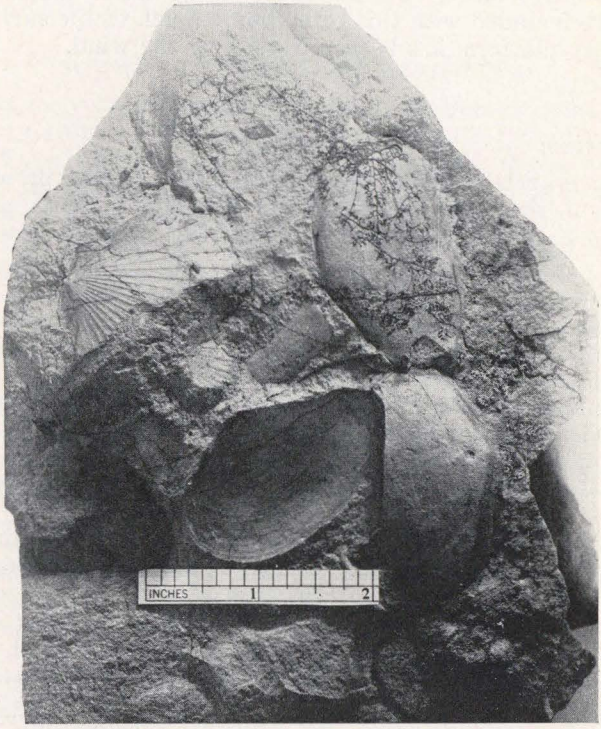


FIG. 12. Wimer shale from Bald Hill showing mollusk imprints.

City and probably part of this formation have yielded *Pecten parmeleei* and *Terebratalia hemphilli* known from the Pliocene of Santa Barbara. The fauna, in the absence of a restudy, is tentatively referred to the

[21] Diller, J. S., *op. cit.*, pp. 32–35.

Pliocene.

Klamath oldland gravels

Stream-laid conglomerates existing on remnants of the Klamath oldland to the east of Crescent City have not yielded diagnostic fossils but are rather generally decomposed to a much greater extent than Recent or Pleistocene gravels. For this reason and from physiographic considerations they are believed to be late Pliocene in age.

These stream deposits of a former erosion cycle are commonly auriferous.

Pleistocene

Battery formation

This is a thin marine-terrace capping of unconsolidated sands exposed over the southern portion of the Crescent City platform. A fossiliferous lens contains a small fauna whose general aspect is that of the upper San Pedro stage. On the map, recent beach sands along the shoreline are included with this formation. Much of the surface of the Crescent City platform has been reworked by the wind.

Recent

Alluvium

Stream gravels occur on terraces in valleys of the present drainage system, in the lower reaches of the principal streams, and in the northern portion of the Crescent City platform, near the Smith River.

Structure

The dominant structural axes of this portion of the Klamath Mountains strike in general north and south. Individual batholiths have similar orientation. For the Siskiyou Range as a whole, however, they are distributed in an east-west direction. Rocks of the region are in most cases metamorphosed and have extremely complicated relationships to each other, testifying to a long and eventful geologic life. Intrusive rocks have by their injection separated and obliterated relationships of the meta-sediments.

To the west of the Siskiyou upland the Jurassic sediments are exposed in north-south belts with bevelled outcrops, with Mesozoic intrusives intervening. The region was apparently the seat of intense orogenic activity at the time of the Sierra Nevadan orogeny in the late Jurassic. At this time the sedimentary series were folded, metamorphosed, and intruded. Uplift and truncation led to the present areal distribution exemplified on the Klamath oldland.

Certain formations have on the whole a homoclinal dip, the Grayback (Devonian) striking northeast and dipping southeast, the Galice though locally contorted, striking nearly north-south and dipping east. The Dothan strikes in general northwest and is folded.

Faulting is prominent both on a large and small scale. Contacts with serpentine usually show displacement. Several faults with displacements of 100 feet or less were observed. Three major fault zones were located. To the east, the Orleans fault of Hershey, a steeply-dipping reverse fault, separates the Siskiyou upland with its igneous-

metamorphic complex from the lower Klamath oldland to the west with its Jurassic meta-sediments and intrusives. The throw has been several thousand feet.

A second line of faulting, perhaps a continuation of the Redwood Mountain fault of Hershey, strikes northwesterly along the west face of the Bald Hills which have been uplifted 400 feet with respect to the area to the west. This fault may continue northwesterly to join the Del Norte fault. The plane of the Del Norte fault has nowhere been observed but is inferred to block out the Crescent City platform and to lie offshore to the south. Structural evidence is afforded by the northeast-dipping Tertiary rocks of the platform which if projected would abut against the Dothan rocks of the oldland province.

The Siskiyou Range in particular and the Klamath mountains in general have been a positive element in the earth's crust during most of geologic time and especially so since the Jurassic. In all the long uplift, dissection, and intrusion, the region has been a massif receiving crustal assaults from all quarters with resulting fracturing, faulting, and metamorphism of the rocks.

SUMMARY OF MINERAL RESOURCES

An extremely varied group of mineral resources is found in northwesternmost California. The deposits are not as a rule of high grade or large. These facts, added to the inaccessibility of this region and high cost of transportation, are responsible for failure to continuously exploit them.

From time to time mining activity has been stimulated by high prices for metals and a number of deposits were exploited for a short time. The first such instance happened in 1863 when copper ore was discovered at Low Divide. Some shipments were made via Crescent City and the ocean. Sporadic prospecting and development work progressed. In 1918 the great demand for metals for war use led to the maximum expansion of mining activity. The mineral most actively sought was chromite because chromium was needed for hardening steel. Del Norte County was the largest producer in the northwest. Some 7903 tons were shipped and 4345 additional tons were mined but not shipped.

The years 1930, 1931, 1932 have seen a marked revival of gold mining which had been relatively unimportant since the activities of the 1850's and 1870's. The high premium placed upon this metal during periods of economic difficulty naturally leads to redoubled efforts in production. Gold has yielded the largest total revenue of any mineral. Placer gold has come from stream gravels of the present cycle, terrace gravels, Klamath oldland gravels and beach sands. Some gold quartz lodes occur but have been on the whole disappointing.

Although unimportant in the past, some cinnabar deposits are being actively investigated and give promise of future development. Such development will be stimulated not only by a higher market value of quicksilver but also by the fact that it can be distilled on the spot, thus eliminating excessive transportation charges.

The occurrence of a number of other minerals may be noted including platinum, osmiridium and awaruite in the placer sands, manganese

minerals, talc, Maoric jade, limestone, etc. Brick clay is found near Crescent City.

The peak production of economic minerals reached during the war did not give Del Norte County a high position among the counties of California. Production declined sharply after the war. During the last few years, as the figures for 1930 illustrate, the crushed rock used in highway construction and the rock quarried for the Crescent City breakwater have increased production values.

COMMERCIAL PRODUCTION [22]

	1917		1918		1930	
Substance	*Amount*	*Value*	*Amount*	*Value*	*Amount*	*Value*
Chromite	3275 T.	$97,255	7143 T.	$360,485	----	----
Gold	----	1,373	----	565	----	$279
Platinum	10 oz.	853	1 oz.	97	----	----
Silver	----	8	----	4	----	1
Stone, misc.	----	2,700	----	8,000	----	175,227
Other minerals	----	2,151	----	2,524	----	523
		$104,340		$371,675		$176,030

[22] Cal. State Min. Bureau, Rept. XVII, pp. 502–503, 1920.
Cal. State Min. Bureau, Bull. 105, p. 136, 1931.

Stream Placers

The gravels of the present stream beds and stream terraces have been rather generally worked throughout northwesternmost California. None of the gravels of the present cycle are being worked steadily but here and there prospectors are operating in a small way. It is quite certain that gold exists in most of the stream gravels and along the bedrock but it is, excepting occasional concentrations, thinly distributed. Gold has been derived from quartz veins and stringers and from old gravel accumulations of a former cycle of erosion deposited on the Klamath oldland.

Smith River was worked in the early days but relatively little was obtained from the north and middle forks. The south fork was rich in places, particularly near creek mouths.

Throughout the drainage system there are accumulations of black sand. Heavy oxides of iron and chromium have been furnished abundantly by the areas of basic rocks. Diamonds have been found in black sands of Smith River. Platinum and osmiridium derived from the ultrabasic peridotites and serpentines have been in part recovered with the gold from the black sand. These metals have not been found in place. At Antone Kauss' mine on Craigs Creek pieces of coarse platinum up to $25 have been found. The gold itself is usually coarse. On Myrtle Creek, it is said, as high as $1,100 has been found in one piece. The nickel-iron alloy, awaruite, also occurs in the black sands. The variety, josephinite, is found on Josephine Creek in Josephine County, Oregon, to the north. The metal is probably not of meteoritic origin but is derived from peridotitic rocks.

Placer properties of doubtful production have been located on Smith River (middle fork) near Gasquet but have not been operated since the completion of the Redwood Highway which greatly increased the value of the land. The tributaries of the middle fork have at times produced gold. These include the Siskiyou Fork, Patrick Creek, and Monkey Creek. On Monkey Creek is a considerable acreage of gravel

bench which at one time was ground sluiced in part. Further development is possible.

The south fork of Smith River and its tributaries have been quite productive and certain locations may be capable of additional development and production. Small bars of Coon Creek and Craigs Creek have yielded small amounts of gold. During the last three years an

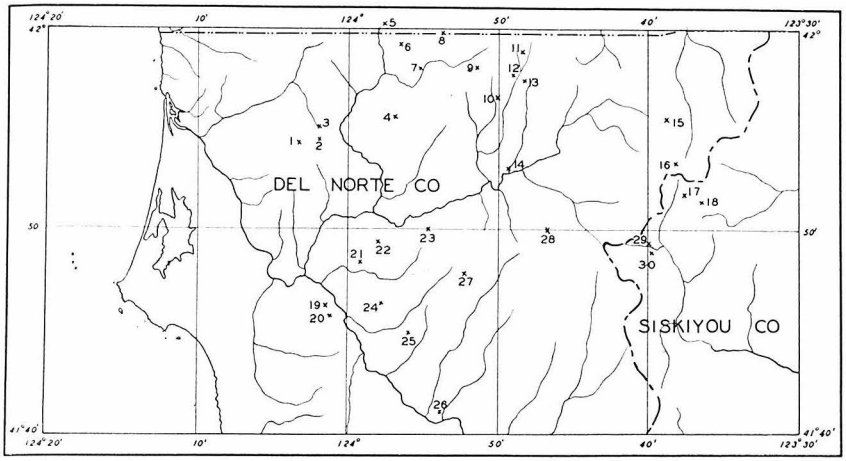


FIG. 13. Index of map of area showing location of mineral deposits.

1. Tyson Rowdy Creek Mine (Chromite).
2. Alta Mine (Copper).
3. Zoar's Chrome.
4. High Plateau Chrome No. 8.
5. Black Beauty Prospect (Manganese).
6. Cleopatra Mine (Copper).
7. Sunny Brook Prospect (Quicksilver).
8. Big Boy Cinnabar Group.
9. Britten Prospect (Copper).
10. Schofield Prospect (Copper).
11. Monumental Mine (Gold lode).
12. Anderson Prospect (Copper).
13. Hard Luck Mine (Gold lode).
14. Monkey Creek Mine (Gold placer).
15. Chicago Camp (Copper).
16. White Feather Prospect (Chromite).
17. The Chromite Prospect.
18. Preston Peak Mine (Copper).
19. Oro Pino Prospect (Gold lode).
20. Ora Anna Mine (Gold lode).
21. Tyson French Hill Mine (Chromite).
22. French Hill Mine (Gold placer).
23. Coon Mountain member of Gordon Mountain Group (Chromite).
24. Coon Mountain Gold Placer.
25. Haines Flat Gold Placer.
26. Big Flat Gold Placer.
27. Gordon Mountain Group (Chromite).
28. Higgins Prospect (Copper).
29. Doe Creek Prospect (Chromite).
30. Bear Mountain Claims.

attempt has been in progress to work bench gravels lying up to 50 feet above Hurdy Gurdy Creek about two miles north of its mouth.

On Jones Creek for about two miles north of its mouth and on its west side a broad terrace lies about 150 feet above the stream. This is Big Flat and it has an area of several hundred acres. Lower terraces are extensive at elevations of 50 feet and 20 feet above the stream.

Work was started here in 1878 by the Big Flat Gold Mining Company which held some 640 acres of gravel. The property was worked from 1882-1889 and a large gold production was reported. After a shut-down operations were renewed in 1895. The gold obtained was coarse. No large-scale operations have been attempted for many years.

Near the mouth of Rock Creek several claims on small stream terraces have been developed by Bill Hudson. The gold obtained is very coarse.

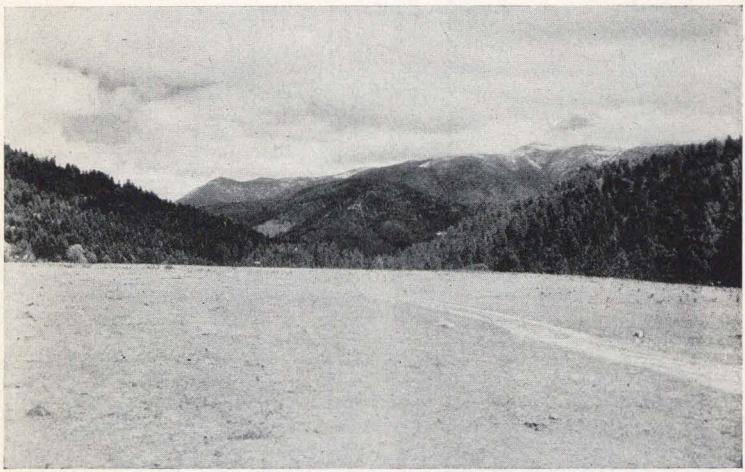


FIG. 14. Big Flat looking northeasterly toward Ship Mountain.

Tributaries to the lower course of Smith River proper have been exploited in the past. On Myrtle Creek in particular a number of placer claims are reported to have been profitable.

Auriferous Gravels of the Oldland Cycle

Gold-bearing gravels occupy valleys of stream courses developed in the former cycle of erosion when the region was worn down to low relief. Patches of these gravels occur on plateaus which have escaped the dissection of the present cycle. Diller's [23] conclusion that auriferous gravels near Waldo, Oregon, were Cretaceous shoreline deposits and Dunn's [24] similar conclusion with respect to deposits on Cottonwood Creek in Siskiyou County, California, have led to statements [25] that the shoreline could be traced through Del Norte County where high-lying gravels occur. The following evidence leads the writer to believe that these gravels are terrestrial. Rounded pebbles are found on many plateau remnants of unequal elevations, i.e. Bald Hills 1900 ft., Childs Hill 2200 ft., Rattlesnake Mountain 3600 ft., Elk Camp Ridge 3300 ft., French Hill 2000 ft., ridge south of Gordon Mountain 2500 ft., Haines Flat 2200 ft., and were apparently deposited by streams on a land surface of this irregularity. On French Hill and Haines Flat the large

[23] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey, Bull. 546, p. 94, 1914.

[24] Dunn, R. L., Auriferous conglomerate in California: Cal. State Min. Bureau, Rept. XII, 1894.

[25] Haley, C. S., Gold placers of California: Cal. State Min. Bureau, Bull. 92, 1923.

gravel accumulations occupy shallow valleys and dip definitely in the direction of valley slope. Shingling of the gravels occurs indicating unidirectional current movement. Pockety distribution of the gold has resulted from current irregularities. The gravels themselves are moderately consolidated, uncemented, though deeply weathered, and have a somewhat recent aspect. The Klamath oldland on which the gravels are found was formed during the Pliocene.

Consequently the gravels are Pliocene, not Cretaceous, and fluviatile, not marine.

French Hill Mine. The French Hill Mine, located on the almost flat summit of French Hill three miles south of Gasquet, is one of the oldest placer properties in the county. Work was started by the Siskiyou Mining Company in 1860. Water was obtained from the headwaters of Craigs Creek. Insufficient water supply proved to be a heavy handicap. The mine is at present owned by the French Hill Mining and Milling Company of which C. P. Terwilliger is president and G. M. Willoughby is secretary.

A newly constructed ditch to Craigs Creek is expected to provide ample water during the winter for operating two or three giants. The

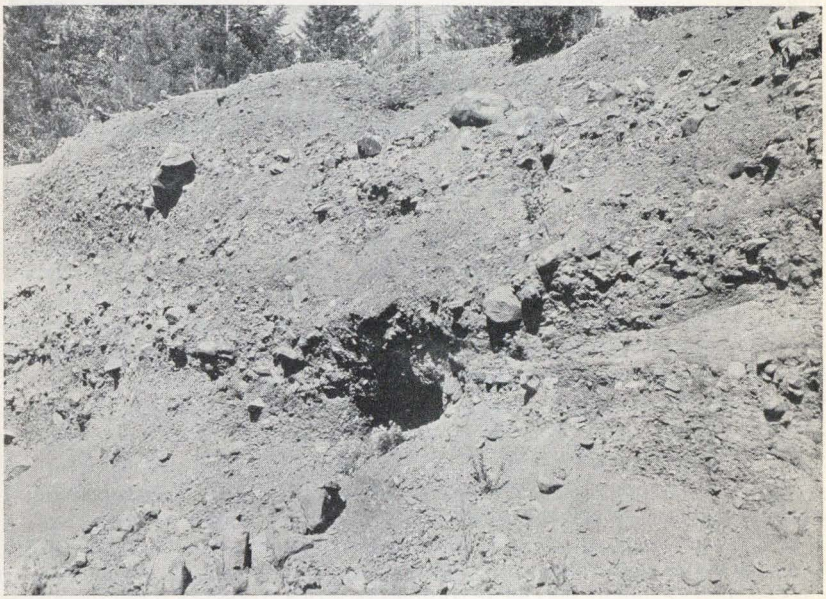


FIG. 15. Gravels of the French Hill Mine.

gravels lie in a shallow southwest-striking valley on the French Hill remnant of the Klamath oldland. The deposit is about 1¼ mile long, 300 ft. wide, and 30 ft. in thickness. The gravels and cobbles are largely of serpentine and diorite from 4 inches to 12 inches in diameter, averaging 10 inches, while some boulders up to 2 ft. in diameter are present.

Metaperidotite and serpentine gravels are usually so thoroughly decomposed that they may be crumbled in the hand. For a few feet

above bedrock they are saturated with water and when exposed to the sun they shrivel and break spontaneously.

The black sand is richest along the dacite (greenstone) bedrock and is spotted in a way characteristic of stream deposits. The gold is coarse and is associated with platinum. During former operations the platinum formed 5% of the total values.

FIG. 16. Looking northerly in the oldland valley of Haines Flat showing former placer workings.

Haines Flat Mine. Work was carried on here in 1877. According to reports mining was never profitable. A large flume and ditch carried water from Gordon Creek to the flat. The Klamath oldland remnant has the gravels preserved in a shallow southward-sloping valley. The deposits are extensive and reach in places 50 ft. in thickness. On the whole they are much finer than those at French Hill.

On the greenstone bedrock is a stratum of fine gravel with some coarse material, then 3 ft. of cobbles, followed by 2 ft. of sandstone which dips about 7 degrees to the southwest. Contrasted with the deposits of French Hill the sorting is good. All the rock types found in the neighboring territory are found in the gravels including metaperidotite, greenstone, diorite, slate, and quartzite. The metaperidotite cobbles have a noteworthy peculiarity: they show a concentric ring of weathered rock about $\frac{1}{2}$ inch in thickness on the outside separated by a thin sheath of quartz from the inside. It is possible that this phenomenon was caused by processes of hydration being continued for a time, followed by mineralization which filled the crevice beneath the expanded shell.

A large cabin was built in the workings with accommodations for a large staff. It is now disintegrating. Several years ago attempts were made to ground sluice some of the gravels, with unsatisfactory results. No information could be gained regarding the character of the gold.

Coon Flat Mine. This property includes an area of gravels on Coon Mountain 5 miles south of Gasquet. They are up to 30 ft. in thickness and occupy a defined channel. Water has been obtained from Coon Creek. The gravels have occasionally been worked by ground sluicing.

Rattlesnake Mountain Mine. A considerable area of gravels on Rattlesnake Mountain, a plateau with an elevation of 3600 ft. about 14 miles south of Gasquet, has been prospected with unsatisfactory gold showings.

Other Oldland Placers. A number of other gravel accumulations of the Klamath oldland remain on certain remnants. Very interesting deposits occur in Josephine County, Oregon, just north of the State boundary of California and south of Waldo. The Osgood or High Gravel Mine has been operated rather regularly over a long period and has produced large amounts of gold. The gravels resemble those at French Hill and rest on a weathered and eroded greenstone basement. They were considered Cretaceous shoreline deposits by J. S. Diller but they appear to the writer to be correlated with the other Pliocene oldland accumulations.

Beach Placers

The beach sands of the Crescent City platform like those of Curry County in Oregon to the north contain large amounts of black sand and considerable values in gold and platinum. A concern known as the Oro Del Norte Company erected a plant two miles south of Crescent City in 1913 and attempted an electromagnetic concentration. The plant was built near the beach and was supplied by a suction pipe and conveyor. The sand was passed to a revolving screen, water was added and the sand and water passed over several plates, the first being large aluminum plates with riffles, the second being small aluminum plates with riffles, and the third a metal plate of unknown composition. An alternating current was passed through the plates and the black sands were supposed to be repelled leaving the gold and platinum. The enterprise failed and no traces of the plant are left.

Small quantities of gold and platinum have been obtained with rockers on Pebble Beach. When the Cresent City breakwater was being constructed it is reported that black sand accumulations in fissures along the bedrock carried fair values.

Gold Lodes

Hard Luck Mine. This property consists of six claims on upper Monkey Creek. Two tunnels were driven on the leached outcrop of a quartz vein. The vein carries arsenopyrite and some gold.

Summit Claim. This is located on the divide between Shelley Creek and Monkey Creek east of Baker Flat (formerly site of Shelley Creek station). Staked by E. A. McPherson and F. A. Sanford.

Monumental Consolidated Quartz Mine. The Monumental Mine was developed by Col. Draper. It consists of eight claims northwest of the old settlement of Monumental on Shelley Creek. They were patented in 1916 and the present owner is the Gunn and Davis Estates. E. A. McPherson of Grants Pass is the local agent. The mine was

worked until 1905 and maintained until 1910. Plans are now under way to unwater and resurvey the workings.

The veins are associated with the east-west contacts of Galice(?) slate and greenstone. This contact dips 70° south. A hoist was built over the hanging wall and the shaft passes into the igneous foot wall at a depth of 70 ft. There are a number of levels with drifts at 40 ft., 100 ft., and 120 ft. The ore was stoped out along the drifts, hoisted, transferred to mule carts and hauled one-half mile down the hill to the mill which is located on the old Gasquet stage road. A large camp was located here.

The ore is soft and leached near the surface but passes into a hard arsenopyrite ore with depth. The gold in the quartz vein is associated with specular iron, arsenopyrite, and some copper minerals. The ore is said to average $40 per ton with the high-grade ore varying from $100–120 per ton.

Ora Anna Mine. This mine is one of the older mines of Del Norte County. It consists of one patented and three unpatented claims on the east side of Bald Hill at an elevation of 1400 ft. There are two parallel veins between a slate hanging-wall and a diorite footwall. The veins average 6 ft. in width, striking east-west and dipping 45° north. They are reached by a tunnel 300 ft. long. The ore consists of free gold, arsenopyrite, and other sulphides. The property has been idle since 1897.

Oro Pino Prospect. This property is on the east side of Bald Hill and is owned by T. S. Stevens. An inclined shaft has been sunk 75 ft. on a quartz vein in decomposed pyroxene diorite. The vein strikes north 46° east and dips north 53°. The gold is fine and flaky. It occurs in pockets in the vein. Associated minerals are pyrite and limonite. Small-scale operations have been in progress during the last few years.

Origin of the Gold

The gold belt of the Klamath Mountains lies in a terrane petrographically similar to that of the Sierra Nevada. Quartz veins in the Klamath region have, however, been only slightly productive as compared with those of the Sierra Nevada. They have, in general, been pockety and discontinuous. The intrusive monzonites and granodiorites correlated with those of the Sierra Nevada were probably responsible for the secretion of the gold-bearing solutions. The fine quartz stringers widely distributed in serpentine and older intrusive rocks during the deep denudation of the Klamath region yielded the gold of the placer concentrations.

COPPER DEPOSITS

History

Copper was discovered in the Low Divide District in 1853. Mines were developed in 1860 and shipments of ore were made to Swansea and Germany. This ore brought $41 to $102 per ton. Between 1860 and 1863 some 2000 tons were shipped from the Alta and Union Mines. After 1870 the district deteriorated. During the heyday of mining activity a typical mining camp of several hundred inhabitants existed

at Altaville. This site is now known only as Low Divide and there are scarcely any vestiges of the former village. Frank Zoar, an old-time miner, is the only inhabitant.

In the later 19th century there was considerable activity in prospecting numerous other deposits in Del Norte and Siskiyou counties.

Nature and Occurrence

The ores of northwesternmost California are usually rich in chalcopyrite. Pyrite and pyrrhotite are also present. Supergene sulphides are of minor importance as are the oxidized copper minerals. The zones of oxidation and enrichment are relatively shallow. Long continued erosion has been in part responsible. Heavy annual rainfall keeps the water table close to the surface. The ore deposits are frequently found in the serpentine or near the contact of serpentine and diorite. In the Preston Peak quadrangle the diorite concerned is usually the Preston hornblende diorite. The veins themselves antedate serpentinization for in some cases they are extensively brecciated, and fragments of ore are coated with serpentine. The major deposits are related to the Siskiyou granodiorite and its correlatives among the Sierra Nevadan intrusives. In Del Norte County the (Cretaceous) Patrick greenstone (dacite and fine-grained quartz diorite) is responsible for some small deposits.

The pyrite-chalcopyrite deposits of Shasta County, California, which have been large producers, are found in alaskite porphyry, presumably the equivalent of the grandiorite of the Sierra Nevada.

To the northwest in Siskiyou County, California, and Josephine County, Oregon, are a number of deposits which may be grouped in three north-south belts. The easternmost one contains the Blue Ledge Mine near the middle fork of the Applegate River in California and several prospects on Squaw Creek in Oregon. The ore of the Blue Ledge Mine occurs in a vein averaging 5 ft. in width increasing to 40 ft. in places. The country rock is a micaceous schist. The chalcopyrite-pyrite ore is said to average 6% copper and $5 in gold per ton. Some 250,000 tons are reported to be blocked out.

The second belt is represented in the Grey Eagle Mine near Indian Creek five miles north of Happy Camp, California. According to the "Mines Handbook" of 1926 the mine is located on a flat-dipping lode varying from 10 to 80 ft. in width. The underground development is extensive. Reserves of 1,045,000 tons of ore averaging 3.23% copper and 40¢ in gold are reported.

The third belt is of immediate interest to this paper and reaches from Preston Peak, north into Oregon. The deposits in California will be described in detail. Those in Oregon near Takilma are especially significant in having been active producers. They have been described by G. F. Kay [26] and by P. J. Shenon.[27]

The Queen of Bronze Mine at Takilma, Oregon, is located on scattered orebodies in serpentine and along contacts with diorite. The nearby Cowboy Mine is similar in the general occurrence. In the Queen of Bronze Mine the largest body removed contained about 10,000 tons. The oxidized zone is less than 90 ft. deep. The primary ore

[26] Diller, J. S., and Kay, G. F., Mineral resources of the Grants Pass quadrangle and bordering districts, Oregon: U. S. Geol. Survey, Bull. 380, p. 76, 1909.

[27] Shenon, P. J., A massive sulphide deposit of hydrothermal origin in serpentine: Econ. Geol., vol. 27, pp. 597–613, 1932.

contains chalcopyrite, pyrite, pyrrhotite, quartz, and calcite. The ore averages 8½% copper with $3 in gold and 17¢ in silver to the ton. The ore is transported to Tacoma for smelting. Reduction in copper values led to closing in 1930. The reported total production is about $1,500,000.

Preston Peak Mine. This property consists of five patented claims on the north slope of Copper Peak and adjacent to Preston Peak. It is reported to be owned by W. T. Thompson and Edgar L. Wallace of Los Angeles. The deposit was one of the pioneer discoveries in the region. It was opened up and considerable underground work was done in 1899 by the Preston Peak Mining Company. Since 1900 no work has been done. Cabins built in Indian Creek Valley have fallen in ruins. The shafts are filled with water.

Mr. K. J. Khoeery of Takilma who had visited the workings gave information regarding the development. The main tunnel was driven southerly in the diorite some 405 ft. At 250 ft. this crosscut an 8-ft.

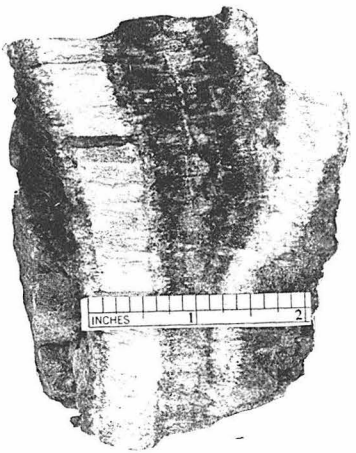


Fig. 17. Asbestos veins in serpentine from Nelson Prospect on Bear Mountain.

vein of chalcopyrite ore averaging 16% copper and $2 in gold per ton. Here a winze was sunk 40 ft. and at this depth the mineralized zone was 40 ft. in width. A 30-ft. drift driven to the west of this orebody disclosed another vein 12 ft. thick containing the oxidized copper minerals.

A large tonnage is indicated by the exploration. Conditions appear favorable to perseverance of ore with depth. The exploitation of this promising ore deposit will probably not take place in the immediate future because of its isolation. It may be reached only by trail and is in the center of a rugged area.

Bear Mountain Prospects. Several copper prospects are located on Bear Mountain near the Devil's Punchbowl. They were located by Fred Nelson, now deceased, who lived at Trout Camp. *Nelson's Prospect* on the north slope of Bear Mountain is located at the contact of serpentine and Salmon hornblende schist. A tunnel 20 ft. long driven south into the ridge has disclosed no trace of ore. The serpentine is

rather generally cut by stringers and veins of asbestos as shown in the accompanying figure. The deposit does not have any commercial interest from this standpoint. The back of the tunnel disclosed some lenticular dikes of altered aplite related to the Siskiyou granodiorite.

Chicago Camp. The Chicago Camp (also known as the *Del Norte Camp*) is located near Whiskey Lake about ¼ mile east of Sanger Peak. Some 178 claims were staked by a Chicago association of claim-holders. An extensive program of development was carried on in 1917 and 1918. Five miles of road were built south of Waldo, Oregon, the whole route of about 10 miles surveyed, and the stumps blasted along the route for two miles north of the camp. The proposed grade of the road would not have exceeded 5%. Cabins, laboratories, and power equipment were installed on the site of the deposits. In connection with the claim-holders association a large sanatorium was begun at Waldo, Oregon. At the end of the war with drop in copper and shortage in funds the exploration ceased. A year later all interests were relinquished by the Chicago group. Most of the claims including the office building are now held by K. J. Khoeery. Waldo itself is deserted and largely in ruins.

The copper deposits of the district do not make an impressive surface showing. Several tunnels have been driven on veins in various parts of the property and some low-grade chalcopyrite-pyrite ore has been removed. It is reported that a magnetic survey and diamond drilling revealed a very large orebody at a depth of 300 ft. As in the other deposits of the region serpentine and diorite figure prominently.

Higgins Copper Group. The group consists of five claims on the east slope of Higgins Mountain. They are on the Siskiyou Fork of the Smith River five miles south of its mouth. A few open-cuts have been made on the oxidized outcrops of veins in serpentine.

Anderson Prospect. This is located one-half mile east of Baker Flat (site of old Shelley Creek Stage Station) and one mile northwest of Anderson's Ranch on Shelley Creek. The veins contain some chalcopyrite and pyrite and occur along the contact of the Patrick greenstone and the Galice slates. Four short tunnels have been driven.

Britten Prospect. The Britten Prospect is about a mile and a half north of High Dome on upper Diamond Creek. The ore-bearing veins are in schist and are associated with some diorite. A shaft 60 ft. deep and a drift of 35 ft. disclosed a 9-ft. vein.

Schofield Prospect. This prospect is located on the east side of Patrick Creek about a mile and a half northeast of the old Patrick Creek station. Two tunnels have been driven east into the ridge on veins in the Patrick greenstone. The ore consists of chalcopyrite in quartz.

French Hill Prospect. An open-cut a short distance west of the French Hill Placer Mine has disclosed a deposit of pyrite and chalcopyrite in the Patrick greenstone. Pyrite crystals are commonly found in outcrops of this formation as at Hiouchi Bridge. The Patrick greenstone is believed to be genetically related to the last four occurrences described.

Cleopatra Mine. The copper deposit is located north of Diamond Creek and just south of the Oregon line in Secs. 3 and 4, T. 18 N., R. 2 E. It is one of the older mines of the region having been opened by an English company in the 60's. Ore was then packed by mule to the old McGrew Road. After its abandonment it passed through a succession of hands. More money was invested without return. The seven claims are now held by Paul Dressle of Grants Pass, Oregon.

Several veins from one to two feet in width have been followed by several hundred feet of underground workings. The veins are in serpentine and are apparently associated with dikes and stocks of diorite. The ore observed was of low-quality pyritic type.

Alta Mine. The Alta Mine was one of the earliest developed in Del Norte County. It has been abandoned for many years. A dump is the only marker of the site where formerly between 1860 and 1870 was located a steam hoist, air compressor, mine buildings, shafts, etc.

FIG. 18. Chalcopyrite-bearing quartz vein from Schofield Prospect on Patrick Creek.

In those days there was an incline 455 ft. deep with four levels and over 1000 ft. of drifts. There was also an adit drift reaching the incline from the gulch. A second vein was opened by a winze below this drift. The Union Mine was located on the northward extension of the Alta vein and had very extensive underground workings. Ore varied from 10% to 18% in copper.

The mines are located on a vein in serpentine which runs north and south on the ridge east of Copper Creek. It dips east 40° to 60°. The principal minerals of the ore are pyrite, chalcopyrite, bornite, and phyrrhotite. Locally there is some supergene enrichment and chalcocite is present.

Zoar Prospect. To the northwest of his cabin at Low Divide, Frank Zoar has several claims. These lie near the head of Copper Creek on

the ridge to the east. Several prospecting tunnels have been driven through the vein. The ore is soft and shows supergene alteration. Chalcopyrite is the principal ore mineral. Samples are reported to run 18% copper.

CHROMITE DEPOSITS

History of Chromite Mining

Chromite was found in the country back of Crescent City before the Civil War. It was brought to the attention of the Tysons in Baltimore who had been mining chromite in Maryland since about 1838. They acquired property on French Hill at Low Divide. From 1869–1873, 1500 tons of ore were shipped annually from Crescent City around Cape Horn to Baltimore. When imported chromite from Greece and Asia Minor reached the United States these Del Norte mines were shut down. There was no further activity until after the World War had begun. Imports from New Caledonia, the principal producer, were practically cut off. After the entrance of the United States into the war the government set about the exploitation of domestic deposits. Large amounts of chromite were mined and shipped. Then the prices broke because of importation of several shiploads of ore from New Caledonia. Chrome mining was demoralized. When the end of the war came a large amount of chromite remained in depots where it may be found today. Operators were partially recompensed for their loss by the government. Since 1918 there has been no activity. Prospects for future activity are not good in view of smallness of deposits, lack of adequate transportation, and cheap sources of supply from Rhodesia and New Caledonia.

Occurrence of the Ore

Chromite deposits investigated by the writer were always found in serpentine or metaperidotite. None was observed in the unaltered rock although such occurrences have been noted.[28] The association with ultrabasic rocks, however, appears universal. Serpentine is widely distributed in the Preston Peak and Crescent City quadrangles and wherever it is present chromite is apt to be found. Chromite prospects are located both in the broad belt of serpentine of the Klamath oldland and in the serpentine stocks of the Siskiyou upland.

The bodies of ore themselves are usually somewhat tabular. They are in reality flat lenses. Although cases of gradational contacts with the country rock are known the lenses studied in Preston Peak and Crescent City quadrangles have sharply-defined boundaries. These surfaces are frequently slickensides.

Nature of the Ore

Minerals

The principal ore mineral is chromite whose formula is $FeO.Cr_2O_3$, representing 68% chromic oxide and 32% ferrous oxide. The iron may be replaced by magnesium and the chromium by aluminum and ferric iron. In this way a gradation may be observed from spinel, $MgO.Al_2O_3$, through picotite, $(MgFe)O.(AlCr)_2O_3$ to the chromite.

[28] Vogt, Zeit. f. prakt. Geol., Jahrgang 1894, pp. 384–393.

Chromite is coal black in a hand specimen. In thin section it is reddish brown. The streak is brown and hardness is 5.5.

Picotite, the chrome spinel, varies in color from yellowish brown to greenish brown. It has not been identified in Del Norte County ores by the writer. The chrome garnet, uvarovite ($3CaO.(AlCr)_2O_3.3SiO_2$), occurs sparsely along the joint planes of the chromite. The green euhedral crystals of uvarovite are usually very small, rarely exceeding a millimeter in diameter. Another silicate, the chrome chlorite known as kammererite or kotschubeite ($4H_2O.5MgO.(AlCr)_2O_3.3SiO_2$), is occasionally found in cavities and along joints. It is a pink mineral of micaceous habit.

Structure

Even-granular structure. This is the common structure of the chrome ore. The chromite crystals are relatively uniform in size. They rarely exceed two millimeters in diameter in the coarsest ore and in the finer types the chromite individuals may be less than 0.5 mm. in diameter. In the most profitable bodies the ore consists largely of closely-packed hypidiomorphic chromite grains with minor interstitial olivine, pyroxene, or serpentine minerals. In the coarser and lower-grade ores the mineral grains are frequently loose making the material very friable.

Disseminated structure. In this type of ore the chromite grains are euhedral and are scattered in a matrix of serpentine. Portions of the Tyson deposit on French Hill contain octahedra or near-octrahedra of chromite in light-green serpentine, each forming about 50% of the total. The chromite was evidently the first-formed mineral. Chromite crystals are intricately fractured as a result of movements during serpentinization.

Nodular structure. This structure has been noted by Diller in ore from Brush Creek, a tributary to Briggs Creek, Josephine County, Oregon. The nodules according to Diller range from one-tenth to three-fourths of an inch in diameter and may be either spherical or ellipsoidal in form. The lentils are usually parallel in orientation. The nodules of chromite are surrounded by the altered primary silicates (olivine and pyroxene). Veins of serpentine cut the nodules indicating their prior formation. The nodules in ore from the Placer Chrome Mine of El Dorado County, California, are cut by veins of serpentine derived from tremolite which was in turn derived from pyroxene.

Banded structure. Chromite commonly occurs in more or less parallel layers which may vary from 5 or 6 cm. in thickness down to about a millimeter. At first sight the black bands of chromite appear to stand out sharply from the lighter-colored alternate layers. It is seen, however, that the bands are not persistent in many cases. The intervening material may be the original olivine and pyroxene or various minerals derived from them. Serpentine minerals, antigorite, penninite, clinochlorite, and chrysotile, are most common. Magnesite is sometimes present. On close investigation it is seen that the contact is not sharp. Chromite crystals along the margin are interlocked with the serpentine minerals. While chromite is concentrated in the bands, secondary minerals are found in interstices and in the bands of sec-

ondary minerals themselves occur scattered chromite crystals. These scattered individuals usually show alignment.

Widely differing theories are held as to the origin of this banding. Vogt [29] illustrates a number of banded chromite ores from Norway and ascribes their formation to the magmatic period. The basis for regarding bands as a flow phenomenon rests in the precedence of chromite in crystallization and its separation before the congealing of the magma. The transecting bands which he mentions are more difficult of explanation and, of course, were formed later. Grout [30] through his studies of the Duluth gabbro rejects many previous ideas of banding of igneous rocks, namely, 1. partial assimilation of inclusions, 2. *lit. par lit* or fluidal gneiss, 3. deformation during solidification, 4. deformation just after solidification, 5. streaked differentiation, with reference to rhythmic cooling or intrusive action, 6. successive intrusions, 7. heterogeneous intrusions. After noting parallelism of banding to boundaries and contacts, he ascribed banding to convection during crystallization.

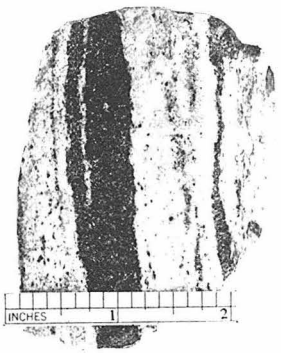


FIG. 19. Banded chromite from the Chromite Prospect on Copper Peak.

Diller [31] in connection with the banded ores of the Hamburg region, Siskiyou County, California, noted parallelism with adjacent gneissic structures and believed the conditions operating to produce the latter also produced the former. Recently Rogers [32] has explained the structure as a replacement phenomenon during a late magmatic stage.

The banded ores of Del Norte County show parallelism to contacts and are believed to have resulted from flowage prior to congealing of the magma.

Origin of the Chromite

Chromite is generally recognized as a product of magmatic segregation. In this respect it is related to magnetite, which also occurs in segregations. Vogt has established the igneous origin of chromite

[29] Vogt, J. H. L., Zeitschr. prakt. Geol., pp. 381–399, 1894.

[30] Grout, F. F., Internal structures of igneous rocks, their significance and origin; with special reference to the Duluth gabbro: Jour. Geology, vol. 26, pp. 439–458, 1918.

[31] Diller, J. S., Chromite in the Klamath Mountains, California and Oregon: U. S. Geol. Survey, Bull. 725-A, p. 18, 1921.

[32] Rogers, A. F., 30th Ann. Meeting Geological Society of America, Cordilleran Section.

deposits in Norway. Diller regarded the deposits of the Klamath mountains as products of magmatic segregation (crystallization differentiation). All the great chromite deposits of the world are found in serpentine. Those of Asia Minor, New Caledonia, and southern Rhodesia are in this rock. Those of Maryland, North Carolina, California and Oregon are similar though smaller. Occasional association of periodotite, pyroxenite, or dunite indicate the original chemical and mineral composition of the magma from which the chromite was derived.

Of late, doubt has been cast on the wholly magmatic origin of chromite. Sampson [33] has suggested the possibility of the serpentinization and introduction of chromite being coincident because of association with hydrothermal minerals. The writer recognizes movement of chromite during the hydrothermal stage. He regards the amounts so transported and deposited as small in comparison with the primary ore. The early crystallization of the chromite of the Klamath deposits has been shown by Diller. In the Castle Crag Mine near Dunsmuir, California, the chromite in places is in direct contact with pyroxenite, dunite, and saxonite. The marginal portions of the chromite are poikolitic with minute serpentine inclusions, the serpentine having been derived from the primary silicates. Thin sections of ores from the Chromite Prospect on Copper Peak north of Preston Peak show penetration of the chromite along fractures by antigorite. Parallel to the contact with the serpentine the chromite crystals are cut by fine, multiple, parallel fractures. The pre-existent chromite lens was thus fractured along its margins by movements during serpentinization resulting from hydration and expansion.

A clear and convincing account of the origin of chromite has been given by Fisher.[34] His conclusions are that there are three periods of chromite deposition which may be stated as follows:

1. Early magmatic chromite, crystallization of chromite well advanced before crystallization of silicates but some overlap.

2. Late magmatic chromite, chromite replaces, surrounds, embays, and cuts cleavable minerals. This exists in largest quantity.

3. Chromite of hydrothermal period, early associated minerals, anthophyllite, actinolite, tremolite, later minerals chlorite talc, kammererite, penninite, magnesite.

Studies of Del Norte County chromite deposits give substantially concordant evidence. Dunite adjacent to chromite lenses in serpentine contains chromite embayed by olivine. Yet some chromite grains in the same thin section exhibiting this phenomenon are interstitial to olivine. Elsewhere chromite has been found concentrated along highly serpentinized fissures in dunite or along contacts between serpentine and chromite lenses. This chromite has probably been dissolved by hydrothermal solutions passing through chromite segregations and chromite-rich silicates and redeposited. Doubt may be expressed whether the late magmatic chromite is as important quantitatively as the early magmatic chromite. It is to be emphasized that chromite of the early magmatic period is very important in developing lenticular

[33] Sampson, E., May chromite crystallize late? Econ. Geology, vol. 24, p. 632, 1929. The comprehensive later paper by this author, Magmatic Chromite Deposits in Southern Africa, Econ. Geol., vol. 27, pp. 113–144 (1932), was not available at the time this study was made.

[34] Fisher, L. W., Origin of chromite deposits: Econ. Geology, vol. 24, p. 691, 1929.

accumulations through crystal settling. The Del Norte County chromite deposits are believed to have formed before the congealing of the ultrabasic magma.

Description of the Deposits

The Chromite Prospect. This prospect is located on the northeast slope of Copper Peak about ½ mile west of Cyclone Cap. It has been held by A. C. Hoofer and George Elder. Some chromite has been mined but none has been shipped.

The deposit is a north-south directed lens in serpentine country rock. The lens is about 40 ft. thick and unknown length and depth. It is probably at least 100 ft. long while a test shaft shows it to be over 20 ft. in depth. In addition to the test shaft there are two tunnels about 20 ft. long.

FIG. 20. Glaciated outcrop of chromite lens in valley of Doe Creek. Lighter patches on top are serpentine.

Most of the ore is massive of the even-granular structure although some banded ore exists near the contact. The chromite is frequently veined with chrysotile and in places is coated with serpentine. Brecciation is general.

Doe Creek Prospect. This is northwest-southeast striking lens in serpentine located on Doe Creek at an elevation of 3400 ft. No exploration or development has been done. The prospect is held by Homer White and Jim Hogue. The lens is about 10 ft. thick, 50 ft. long, and of unknown depth. It is shown in Figure 20.

White Feather Prospect. This prospect is located on the ridge east of Young's Peak. It is a lens in metaperidotite which on the surface appears small. No development save a small open-cut has been

done. The chromite appears to be high grade. The prospect has been held by A. C. Hoofer and George Elder.

The White Feather and the two previously described prospects are unfavorably situated with respect to transportation. Ore would have to be carried by pack train for about 12 miles. This feature will undoubtedly prevent development for many years.

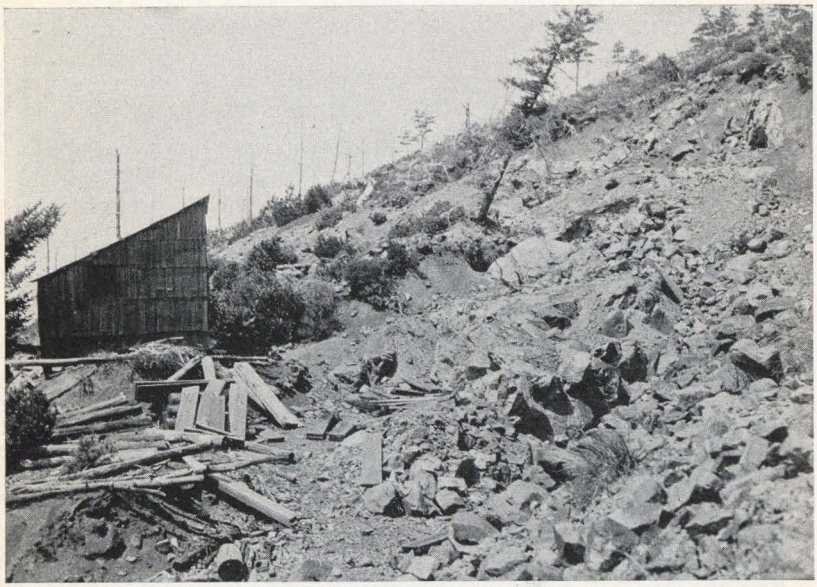


FIG. 21. Workings of High Plateau Chrome No. 8 looking northwesterly along the strike of the lens. Body bounded sharply by joint planes.

Gordon Mountain Group. The group of chromite deposits on and about Gordon Mountain were operated by the California Chrome Company during the World War. Much preliminary labor was required to render them accessible. The road was extended from French Hill some six or seven miles to Gordon Mountain. Since abandoning of the deposits the U. S. Forest Service has extended this road south to Big Flat.

The group consists of five deposits, the Zinc Saddle, No. 7, No. 8, Rowen, and the Madrone. To the southwest of the highest point on Gordon Mountain a short distance is a chromite lens in serpentine. Most of the body appears to be buried and comparatively little worked by open-cut. The shaft is filled with water to within 30 ft. of the surface.

Another chromite lens in serpentine occurs on the slope north of the gap between French Hill and Coon Mountain. This lens strikes northwest-southeast and varies in breadth from 10 ft. on upper slope to 20 ft. lower down. The ore was high grade but relatively small in amount, much of the body having been eroded away. Some of the ore contained admixture of serpentine.

French Hill Mine. This mine was one of the first located on Del Norte chromite. It is owned by the Tyson Mining Company of Balti-

more, Md. The mine is located on the southern margin of French Hill at an elevation of 1700 ft.

The ore lens strikes northwest-southeast and plunges south beneath the hill slope. It lies in the serpentine at the contact with micaceous schist on the east. This schist strikes north-south and dips about 30° east. The serpentine is extraordinarily brecciated and contains scattered small pieces of chromite. Much of the ore is of even granular structure but near the northwest part of the deposit a low-grade disseminated ore appears. This ore consists of euhedral chromite individuals in a matrix of serpentine.

The ore was mined from a glory hole about 50 ft. in diameter and removed through two tunnels striking the orebody about 50 ft. below the surface. The ore was transferred to trucks. The wooden bunkers have slid into the road with about 15 tons of ore in them.

High Plateau Chrome No. 8. This deposit was one of the largest producers in 1918 when it was owned by E. J. Hawkins of Crescent City and operated under lease by Adams and Maltby. It lies on the north slope of Low Plateau at an elevation of 2700 ft. in the north half of Sec. 28, T. 18 N., R. 2 E. A narrow-gauge road from 5 to 6 ft. wide was built up Diamond Creek to connect with the Wimer Road. In 1918 the ore was transferred from the bunkers to narrow-gauge Ford trucks which carried it to bunkers at the junction with the Wimer Road. Here

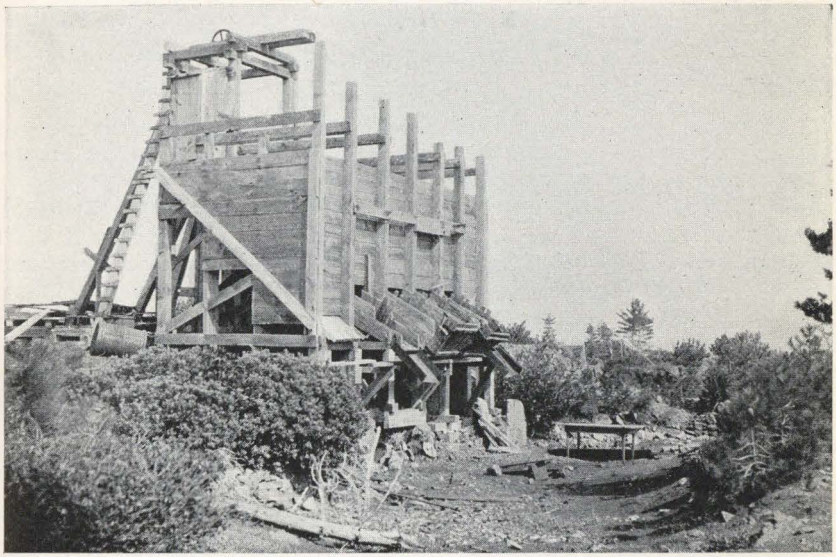


FIG. 22. Hoist and bunkers over ore lens, Tyson Rowdy Creek Mine.

it was passed via standard-gauge trucks to Grants Pass. The deposit is now claimed by A. P. Jepson.

The orebody is arcuate, striking in general northwest. In places the lens is shallow. While many tons have been removed a large quantity remains. The contact with serpentine is not sharp and small nodules of chromite are found in the adjacent country rock. Toward

the northwest end a cross-section of the orebody may be seen. The north 1½ ft. is of high-grade ore probably running over 52% chromic oxide. About 20 ft. of low-grade ore is exposed to the south. The chromite in this ore is coarsely crystalline with a matrix of decomposed serpentine minerals. This ore is very friable. Chrome garnet and chrome mica are common.

Rowdy Creek Mine. This mine is owned by the Tyson Mining Company and consists of one claim located on Rowdy Creek (Copper Creek) and three claims on High Divide Mountain about 2 miles southwest of Low Divide itself. High Divide Mountain is flat-topped, an oldland remnant, lying at 2200 ft. elevation.

The orebodies are lenses in serpentine and dunite. The main body was worked through a shaft now filled with water to within 40 ft. of the surface. A hoist and dump fed ore to the bunker whence it was passed to trucks. The ore was transferred at Crescent City to ships. The lenses strike northwesterly. Those to the northwest of the main orebody were mined by open cuts.

Most of the ore is of even-granular structure but some is banded chromite and serpentine.

Zoar's Chrome. This lies 100 ft. southwest of the cabin at Low Divide and is owned by Frank Zoar. The ore occurs in a vein 8–10 inches wide and as nodules in serpentine. About 40 tons of 54% ore were removed during the war.

QUICKSILVER DEPOSITS

History

Cinnabar was discovered on Diamond Creek in the northwest ¼ of Sec. 11, T. 18 N., R. 2 E., in the early 50's. At that time placer miners from as far as Kerby, Oregon, a distance of 35 miles, went there to obtain mercury for amalgamation processes. It is reported by K. J. Khoeery who obtained his information from Bill Wimer that a shaft was sunk on the cinnabar ledge. A fire was built in the shaft and mercury condensed on the walls, which were wetted occasionally to keep them cool. After such crude roasting the quicksilver was collected from the bottom of the shaft. The property was first located by an English company in the 60's. It was claimed by many others thereafter. In 1916 it was claimed by John Taggart and associates of Smith River. They built a retort in 1917 with three units and underdraft. Three-inch pipe condensers ran into water. The retort had a capacity of 500 pounds of ore and was retorted for six hours. One flask of quicksilver was recovered in 1917 when operations ceased. It was found that most of the quicksilver was being lost.

Sunny Brook Prospect. This property is now held by Lee Brown of Los Angeles, who has two center claims, and by John Taggart of Smith River, who has two claims to the south and one to the north. In 1930 some development work was being done. The main shaft which was caved in 1917 was being uncovered.

The ore mineral is cinnabar, HgS, which occurs in stringers in quartz veins with serpentine country rock and in fissures in the serpentine itself. There seem to be two parallel lodes striking due north. These are much fissured. They may be associated with the broad dikes

of hornblende diorite outcropping 100 ft. to the northwest. These may have served as the source of the ore as they are also associated with the Big Boy cinnabar deposits.

The workings and retort are on an extensive terrace on the northwest side of Diamond Creek. Above the ledge is an overburden of a few feet of creek boulders. A cut has been made 100 ft. north of the retort which is 40 ft. long in a north-south direction and 10 ft. in width. A crosscut below the creek level is being driven to connect with the old tunnel. In this working bunches of native quicksilver were found along the strike.

Some of the ore seems to be of good grade running from 1% to 2% mercury. The average run is reported to be 10 pounds of mercury to the ton.

Big Boy Cinnabar Group. The Big Boy cinnabar deposits lie on the north fork of Diamond Creek at an elevation of 2150 ft. They are four miles northeast of the Sunny Brook Group. Two claims in Curry County, Oregon, are owned by R. E. Strayner and J. J. Hoogstraat. Three claims in California are owned by O. H. Hagberg, H. W. Lipple, and George Davis. The group is operated under a partnership arrangement.

The cinnabar is not found in the typical vein occurrence but is scattered along fine joint fissures in a huge mass of propylitized diorite.

FIG. 23. Sunny Brook cinnabar ledge on Diamond Creek.

In this rock the feldspars have completely altered to kaolinite, and to sercite, and the amphiboles to limonite, etc. The altered diorite is exposed over the top of the ridge west of the camp, and on the west is in contact with or continuous with the dikes passing near the Sunny Brook Prospect. On the north is a tongue of serpentine while to the

east less-altered rocks occur including a fresh hornblendite or gabbro containing inclusions of serpentine.

The alteration of the diorite is not believed to be the result of meteoric waters connected with the Klamath oldland stage, although remnants of this surface are found nearby. Rather the cinnabar was introduced and then the rock was altered simultaneously by pneumato-

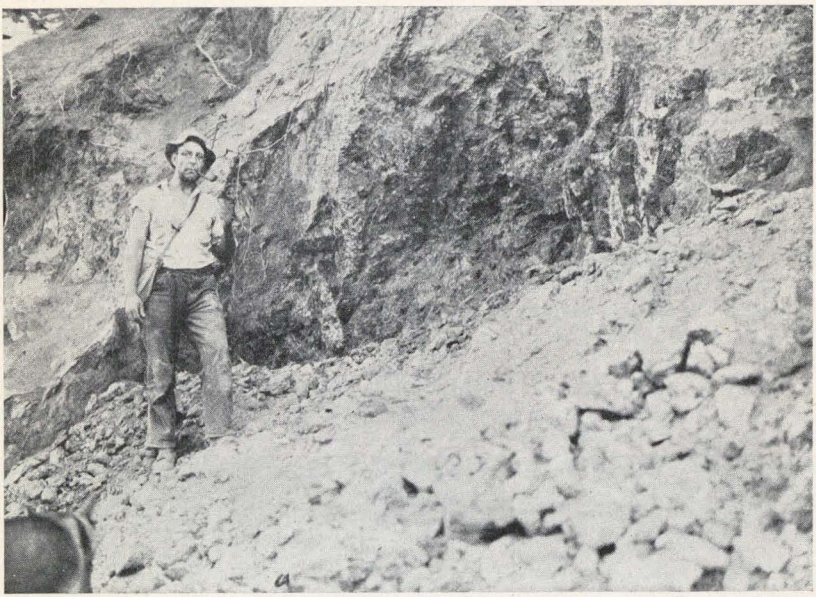


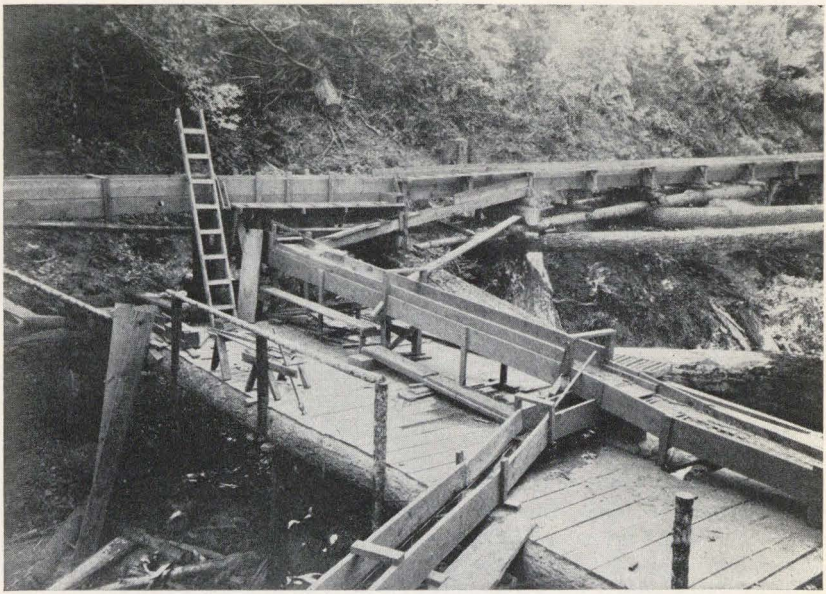
FIG. 24. Propylitized diorite of Big Boy Mine containing cinnabar along joint fissures.

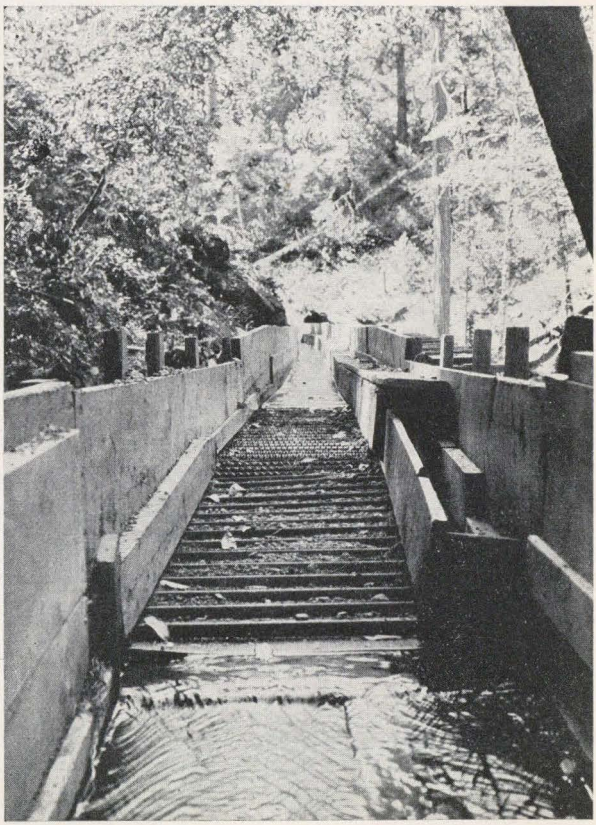
lytic action in a late magmatic stage. This view is significant in implying alteration and mineralization to an unknown presumably great depth.

Thus the deposit is very large. A report by W. A. Hutton estimates that it contains 25,000,000 cu. yds. carrying 3–5 pounds of cinnabar to the ton. The difficulties encountered are principally connected with the concentration of this low-grade ore.

The original locator, John Griffin, put in a ditch along the top of the ridge and ground sluiced what was originally a small slide. The water was run through a 10-inch sluice box with Hungarian block riffles. The concentrates were retorted in two 4-inch pipes.

The present equipment, installed by the J. I. L. Dredging Company of Spokane, which leased the property, is essentially a refinement of the above. A 3-inch giant was operated in the slide and the material run through a series of sluices making a gravity separation. It was hoped that in this way the heavier cinnabar crystals could be concentrated. The process was extremely inefficient, however, and the property is at present idle pending installation of more efficient equipment.





FIGS. 25 and 26. Sluice boxes for cinnabar gravity separation.

MANGANESE DEPOSITS

Black Beauty Prospect. This prospect is located on the east side of the north fork of Smith River at an elevation of 1400 ft. It lies in southeastern Curry County, Oregon, about one mile north of the State boundary. It was located in 1918 by John Taggart, James Keaton and Reves Costello and restaked in 1924. Its present ownership is in doubt.

The deposit appears to be a replacement body along a brecciated zone in Dothan cherts and jasper. The surface outcrop on the slope of the hill is 65–70 ft. in width and runs 150 ft. or more in a direction N. 35° W. The ore minerals are pyrolusite and manganite. The oxidized zone extending to the depth of exploration (15 ft.) has considerable wad. The gangue consists of suspended chert fragments and porous silica.

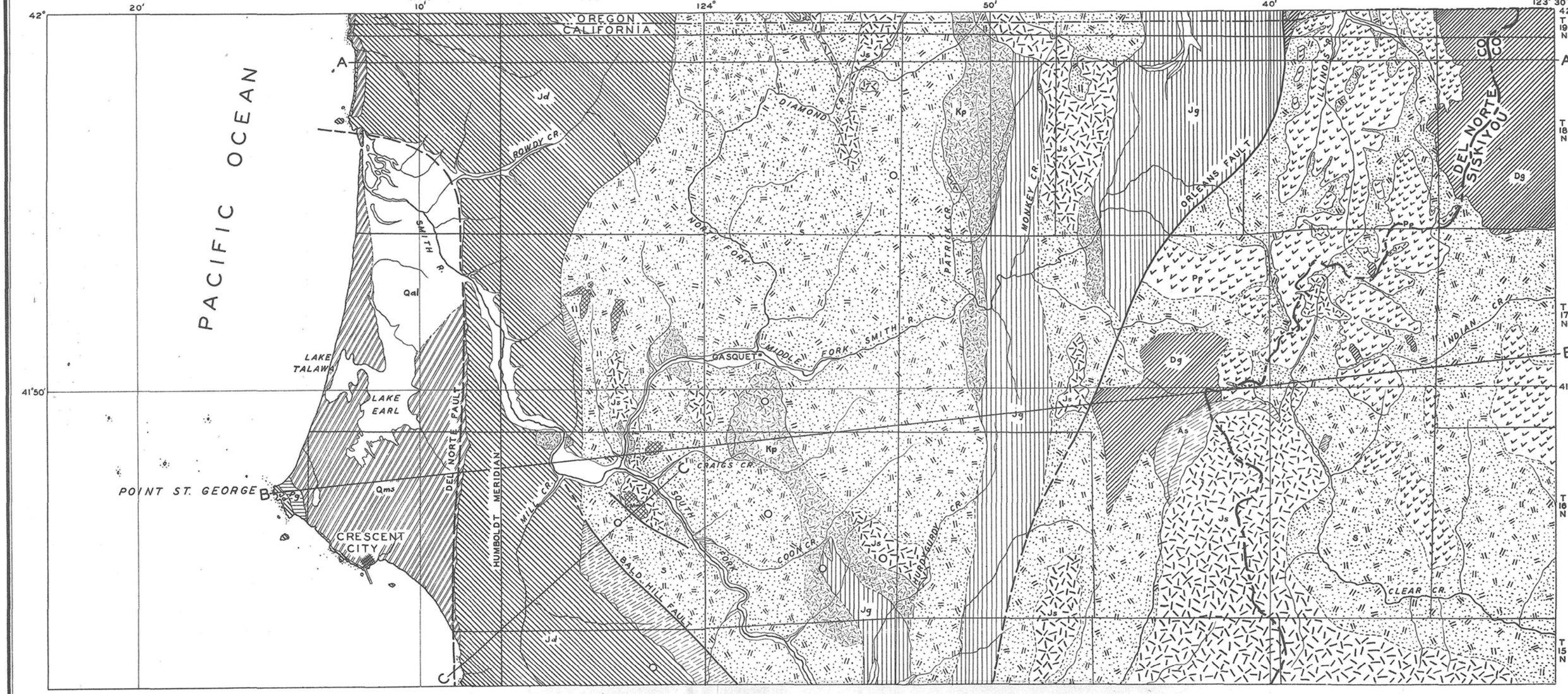
The ore is reported to be of high grade, namely 72% manganese dioxide, but so far as may be seen from the exploration such high-grade ore occurs only in small masses. With depth, however, the chances for high-grade ore appear good.

The development is small and consists of a cut and tunnel extending 30 ft. to the east from the face of the hill. The ore disappears at the back. One short cross-cut extends to the north of the open-cut. Observations indicate that the orebody dips about 60° southwest. A cabin has been built south of the workings.

CALIFORNIA STATE DIVISION OF MINES
WALTER W. BRADLEY, State Mineralogist

PLATE IV

GEOLOGIC BRANCH
OLAF P. JENKINS, Chief Geologist



GENERALIZED GEOLOGICAL MAP OF NORTHWESTERNMOST CALIFORNIA

GEOLOGY BY J. H. MAXSON 1930

SCALE 1 0 1 2 3 4 5 MILES

—— CONTACT ----- CONTACT, APPROXIMATE —— FAULT —— — FAULT, APPROXIMATE

QUATERNARY	Qal	RECENT ALLUVIAL GRAVELS	MIOCENE	Mw	WIMER FORMATION	JURASSIC	S — SERPENTINE-PERIDOTITE
	Qms	BATTERY FORMATION AND RECENT	CRETACEOUS?	Kp	PATRICK GREENSTONE		Jd — DOTHAN FORMATION (FRANCISCAN FORMATION)
PLIOCENE (?)	Pg	ST. GEORGE FORMATION	JURASSIC	Js	SISKIYOU GRANODIORITE		Jg — GALICE FORMATION
				O	OCCURRENCE OF KLAMATH OLDLAND GRAVELS	PALEOZOIC?	Pp — PRESTON DIORITE
						DEVONIAN	Dg — GRAYBACK FORMATION
						ALGONKIAN (?)	As — SCHISTS